

# GLOBAL MARKETS, GLOBAL TECHNOLOGY, AND GLOBAL STUDENTS?

A COMMUNICATIONS CONTRIBUTION TO THE  
WORKSHOP,  
“THE FUTURE OF & TECHNOLOGY”  
UNIVERSITY OF FLORIDA @ GAINESVILLE

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University of Florida  
THE

DEPARTMENT OF ELECTRICAL ENGINEERING

With the approval of the Faculty  
hereby recognizes the permanent appointment of

ULRICH L. ROHDE

as

Professor of Electrical Engineering



March 15, 1977

Wayne H. Chen  
Dean, College of Engineering

Donald T. Childers  
Chairman, Department of

# The George Washington University



THE  
*DEPARTMENT OF ELECTRICAL ENGINEERING*

With the approval of the Faculty  
hereby recognizes the permanent appointment of

**Ulrich L. Rohde**

as

**Adjunct Professor of Electrical Engineering**

*Arthur D. Friedman*

Arthur D. Friedman  
Chairman, Department of Electrical

May 4, 1982



## **GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS**

Using the example of the cell phone industry

# International communications market

- The technologies involved are a combination of analog and digital applications as well as passive and active components.
- The globally/universally useful RF engineering additionally understands
  - A/D converters
  - DSP, digital signal processing (DSP),
  - Micro processor coding in C++
  - Business education (MBA)
  - Innovative design with an eye for quality and reliability of the product.

## Analog Technology, Examples

- RF front ends consists of
  - Analog low noise preamplifiers
  - “Linear mixers”
  - PLL based synthesizers with low power consumption
- Design parameters may be:
  - Noise figure, i.e.:  $< 1\text{dB}$
  - Intermodulation distortion  $\text{IP3} > 1\text{dBm}$
  - Input selectivity,
  - Phase noise ( $-145\text{dBc/Hz}$  @  $200\text{KHz}$ )
  - Settling speed, less than  $1\text{mS}$

# Digital Technology Example

- Analog to digital converters (A/D)
  - Optimized IF frequencies
  - impedance matching
  - Overload vs. noise figure
- Design decisions may be:
  - IF selectivity
  - Coding scheme
  - Composite filters implementation in DSP
  - Automatic gain routines
  - Computational delay time

# ANALOG AND DIGITAL TECHNIQUES



**Broadband Wireless Solutions...**

**...from 1 to 60 GHz**

**UNBEATABLE MMIC SOURCE**

UMS is the "one stop" supplier of integrated circuits covering the broadband wireless requirements from very low noise to high power, using PHEMT technologies up to 94GHz.

The advertisement features a large image of a radio tower and a satellite dish in a field of sunflowers. A circuit diagram is overlaid on the image, showing various components like 'Up Converter', 'Down Converter', 'MMIC', and 'PHEMT'. The text 'UNBEATABLE MMIC SOURCE' is prominently displayed in yellow and red. Below the main image, there are four smaller inset images: a person talking on a mobile phone, a satellite in space, a close-up of a circuit board, and a close-up of a satellite dish.



# HIGH PERFORMANCE ANALOG TECHNIQUES

## AN EXAMPLE

### HIGH IP3 MIXERS

When your wireless communications system calls for very low intermodulation distortion and enhanced dynamic range, look into Synergy's new line of **HIGH IP3 MIXERS**. Standard models are available in specialized frequency bandwidths covering UHF, Cellular, PCS and ISM bands. Additional features are low conversion loss and high interport isolation. Most models operate at +17 dBm of local oscillator drive level and exceed +30 dBm of input third order intercept point. Higher L.O. drive level models with higher third order intercept points are also available.

Don't compromise performance...  
specify Synergy's **HIGH IP3 MIXERS**.

For additional information,  
contact Synergy's sales and application team:

Synergy Microwave Corporation  
201 McLean Boulevard, Paterson, NJ 07504  
Tel: (973) 881-8800 ✦ Fax: (973) 881-8361  
E-mail: [sales@synergymwave.com](mailto:sales@synergymwave.com)  
Web site: [www.synergymwave.com](http://www.synergymwave.com)

**SYNERGY**  
MICROWAVE CORPORATION



## **GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS**

Using the example of the cell phone industry

# Evolution of the cellular technologies



# EVOLUTION OF DIGITAL CELLULAR TECHNOLOGIES

**2G**

**Mainly GSM**

Narrowband 270 kHz

Few frequencies  
900/1800/1900 MHz  
No global frequencies

Low datarates, initaly  
9.6 kbps evolving up to  
384 kbps

Very high latency

**1991**

**3G**

**Mainly WCDMA**

Bandwith 5 MHz

Initially 2.1 GHz almost  
global availability  
Evolved to a global  
standard

Data rates 384 kBit/s  
evolving to 42 Mbit/s

Medium latency  
Suffered from IPR  
fights

**2002**

**4G**

**LTE**

Flexible bandwidth up  
to 20MHz

Deployed from 400  
MHz to 3.7 GHz

Data rates from 40  
Mbit/s to todays 1.2  
Gbit/s

Low latency

**2010**

**5G**

**5G NR (New Radio)**

Scalable bandwidth up  
to 2000 MHz

Frequencies up to 71  
GHz

Very high data rates

Ultra low latency  
possible

**2019**

# HAS 5G DELIVERED ON ITS PROMISES?

## YES AND NO

- ✓ Download speeds are up, latency is down
- ✓ Is the “playground” where new features are being developed
  - ✓ Non terrestrial networks
  - ✓ Reduced capabilities devices
- Current 5G networks are more 4.9G networks maintaining legacy 4G functionality
  - Increased user equipment complexity, cost and power consumption
- Slow take up on low latency and Internet of Things (IoT) applications



# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Winners and others: Some examples

# Winners

## Apple

- Entered the mobile world 2007
- Most profitable manufacturer since 2009

## Samsung

- Scale of economy
- In house touch screen expertise
- Worlds largest manufacturer

## Google

- Android has 85% market share as mobile OS
- 38% of all devices connected to the internet are using Android
- 2021 – 3 billion active devices

# Others

## Nokia

- 2009 the largest cellphone maker in the world
- Too proud to adopt Android
- Strong innovation culture – failed to bring innovations to the market – sold to Microsoft – Name sold to HMD
- Most profitable since manufacturer 2009

## Motorola

- Sold to Google – sold to Lenovo

## Ericsson

- Cellphones was a mean to sell infrastructure - when 3G matured – not able to compete.
- Sold to Sony

## Blackberry

- Focused on messaging
- Missed the touch screen revolution

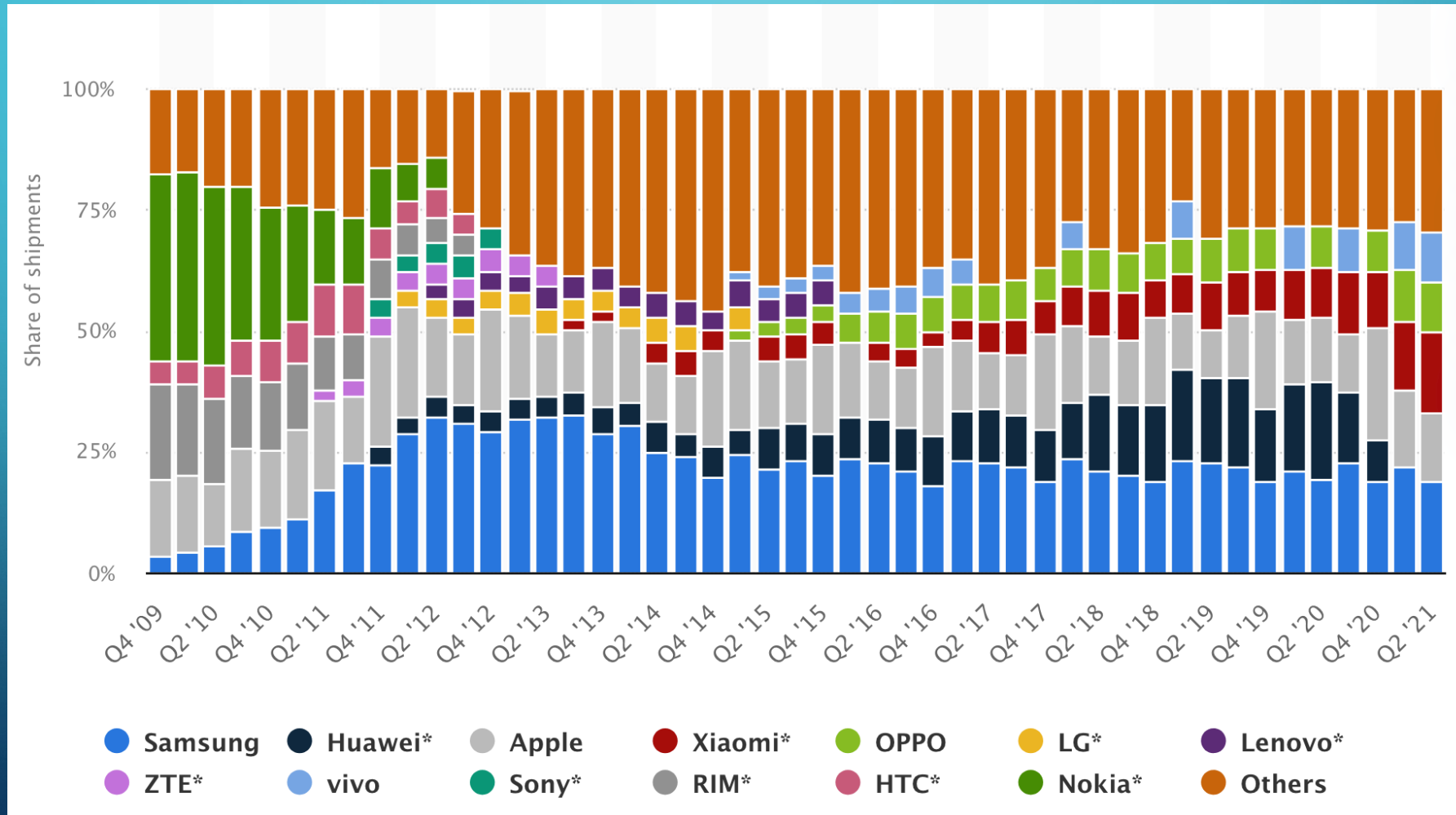
## Huawei

- First cellphones 2003
- 2019 worlds second largest supplier of smartphones
- "Killed" by US trade sanctions –Renamed to Honor -sold



# CELLPHONE SHIPMENTS UNTIL 2021

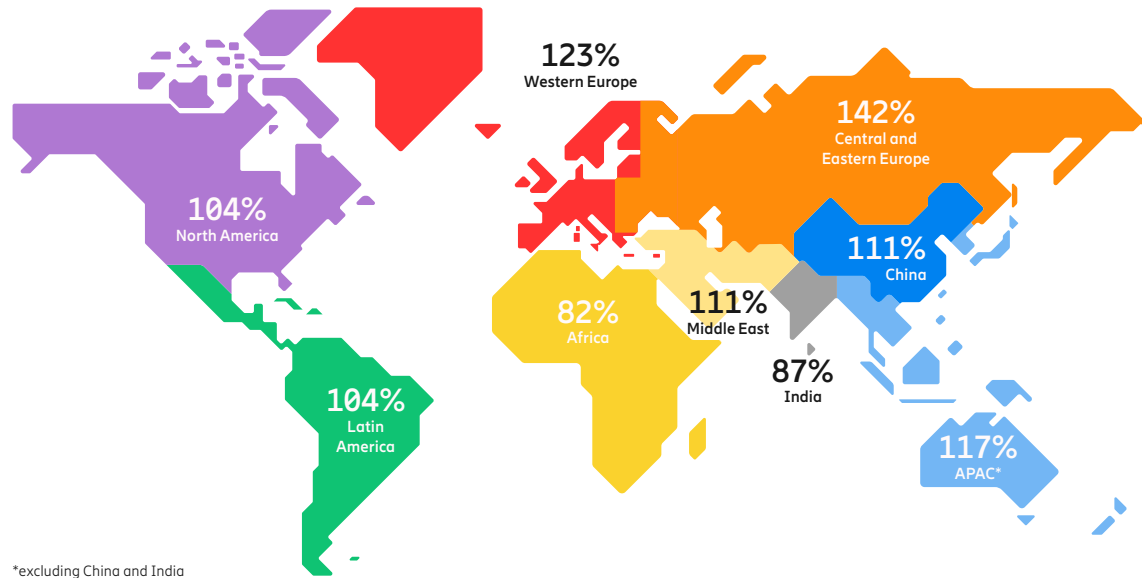
SOURCE: WWW.STATISTA.COM





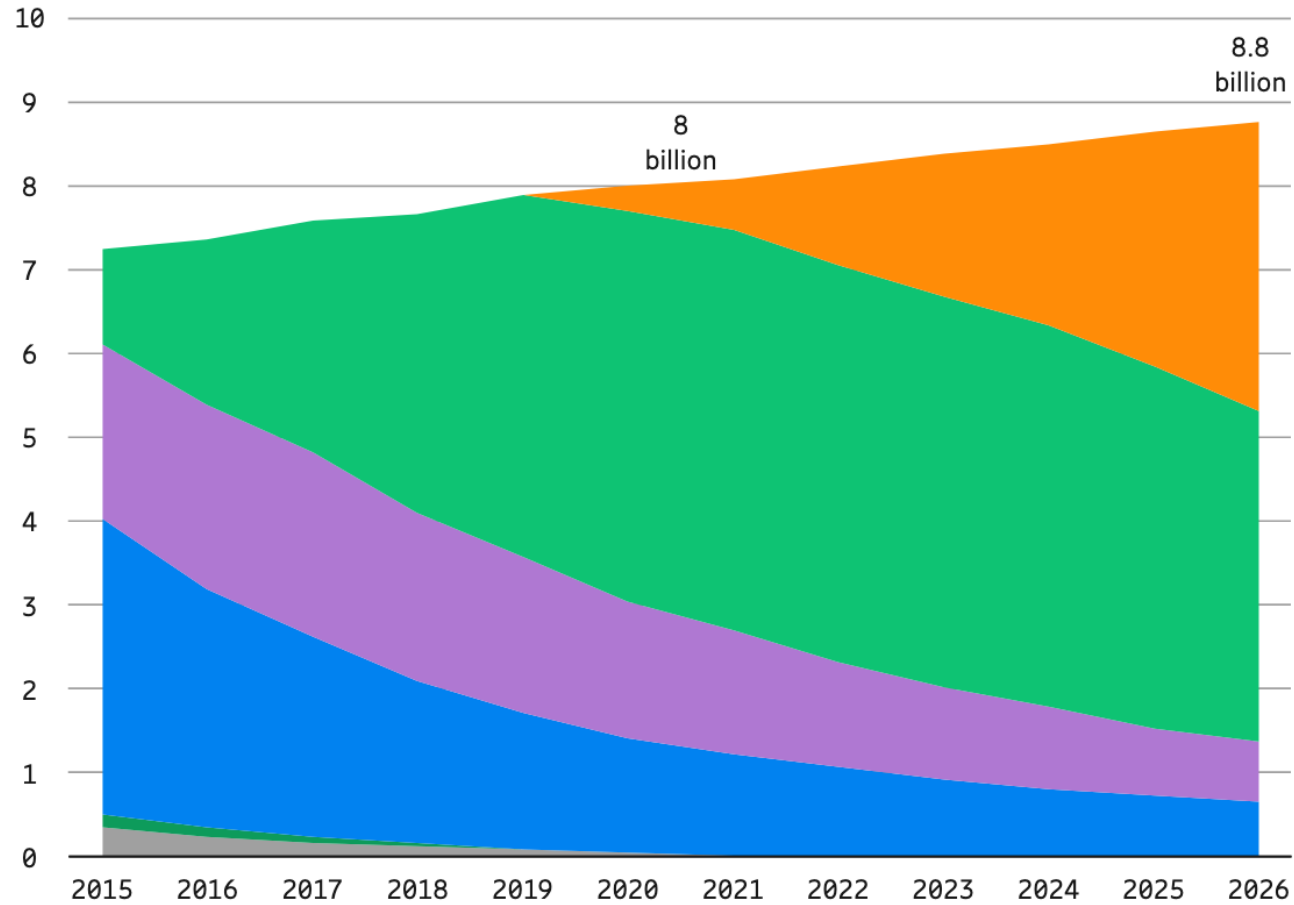
## **GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS**

**Looking Forward: What will drive the technological  
development?**



LTE A TRUELY GLOBAL TECHNOLOGY  
SUBSCRIPTION PENETRATION 2018  
SOURCE: ERICSSON MOBILITY REPORT

Figure 1: Mobile subscriptions by technology (billion)



# 3.5bn

In 2026, 3.5 billion 5G subscriptions are forecast.

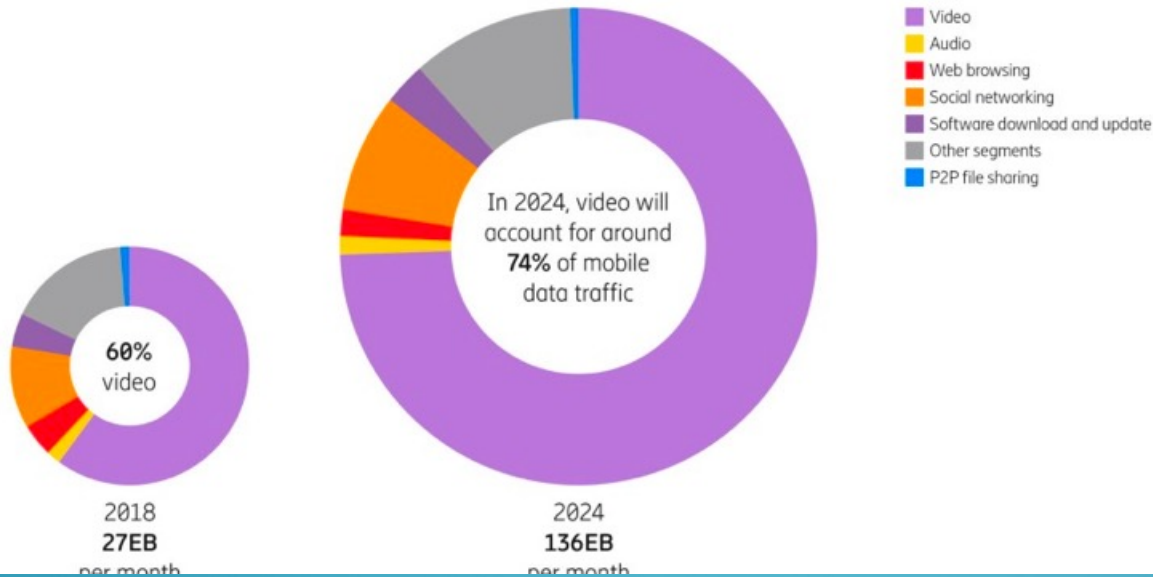
- 5G
- LTE (4G)
- WCDMA/HSPA (3G)
- GSM/EDGE-only (2G)
- TD-SCDMA (3G)
- CDMA-only (2G/3G)

Note: IoT connections are not included in this graph. Fixed wireless access (FWA) connections are included.

## THE FUTURE OF WIRELESS TECHNOLOGIES

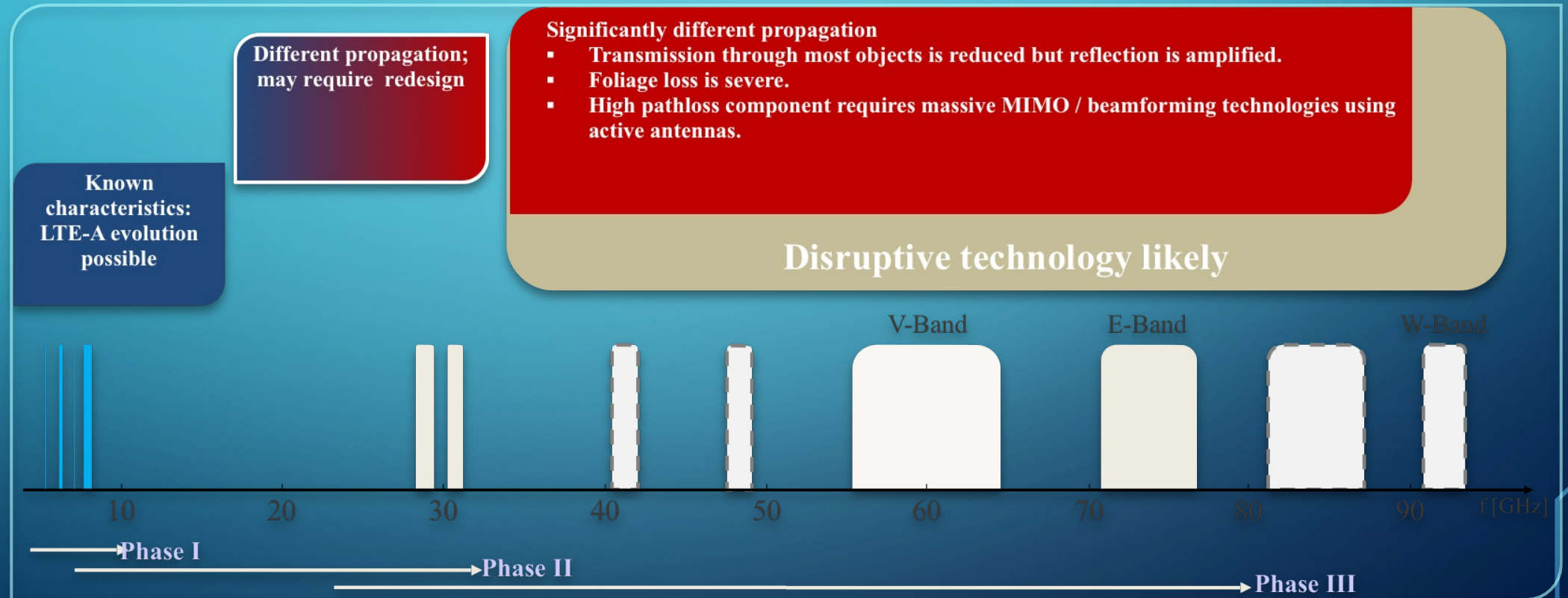
SOURCE: ERICSSON MOBILITY REPORT

Mobile data traffic by application category per month (percent)

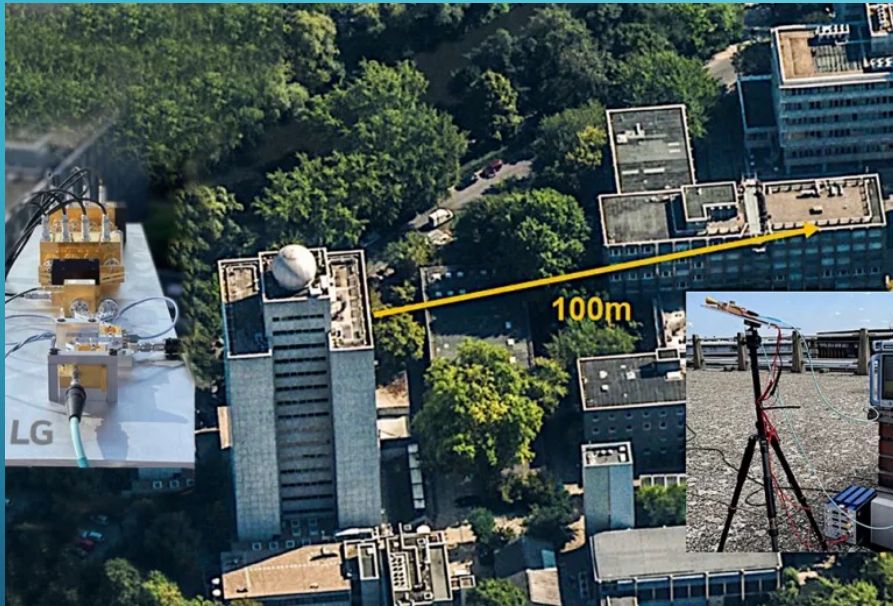


# DATA WILL BE DRIVING THE FUTURE OF THE CELLULAR INDUSTRY

# HIGHER DATA RATES REQUIRES BANDWIDTH ONLY AVAILABLE AT HIGHER FREQUENCIES



# FIRST 6G DEMOSTRATORS USING D-BAND AIMING FOR COMMERCIALIZATION 2029



<https://www.lgnewsroom.com/2021/08/lg-records-6g-thz-band-milestone/>

# WHAT CAN WE EXPECT FROM 6G IN 2030?

## SOME CURRENT REASEARCH ARE

- Faster data transmission using higher frequencies & wider bandwidth
- JCAS – Joint communication and sensing combining communication and “radar” like functions
- AI and ML for better performance
- RIS – Reflective intelligent surfaces for better and dynamic coverage
- New network structure with LEO and GEO satellites, drones and others to provide true worldwide coverage
- Increased security



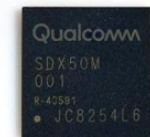


## GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

How has the cellphone antenna developed over the years ?



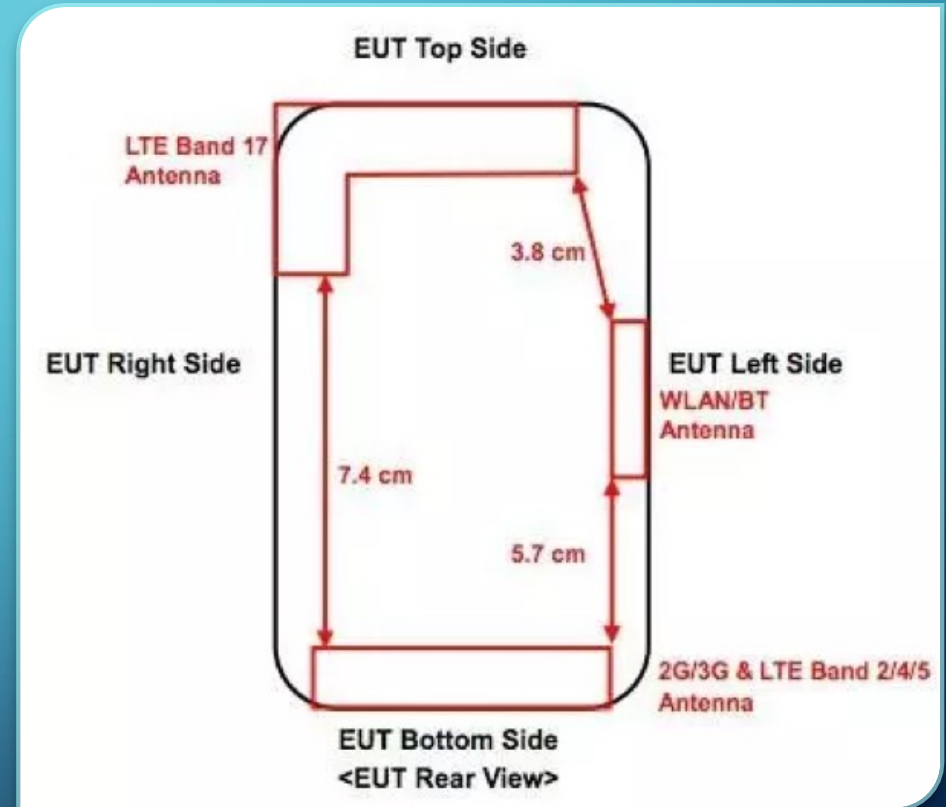
**Qualcomm QTM052 mmWave  
Antenna Module & Snapdragon  
X50 5G modem**



# Antennas in a modern cellphone

## Not just one antenna

- Up to 10 different frequency bands
- Multiple cellular technologies:  
GSM, UMTS, LTE, TD-SCDMA
- Non cellular technologies: WiFi, Bluetooth, GPS, Glonass, Galileo, Baidu, NFC
- Receive diversity antennas



# 5G AND ENERGY CONSUMPTION

- Current 5G devices consume more energy when using 4G+5G (NSA)
- 5G devices with low (FR1) and high frequency (FR2) consume more than devices with FR1 only
- Most of the power in a cell phone is used during monitoring of control information
- Improvements to increase efficiency is being standardized
- 5G Networks consume less power than 4G Networks
- Energy consumption is a major expense for network operators

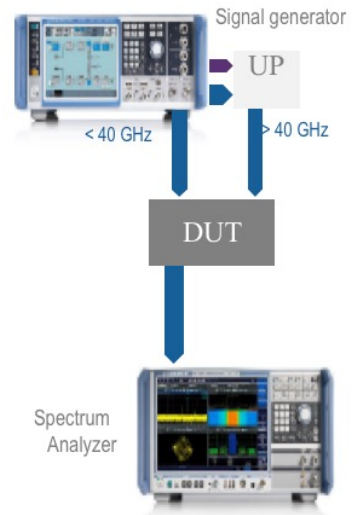
<https://www.ericsson.com/en/blog/2020/2/mobile-devices-and-energy-efficiency>



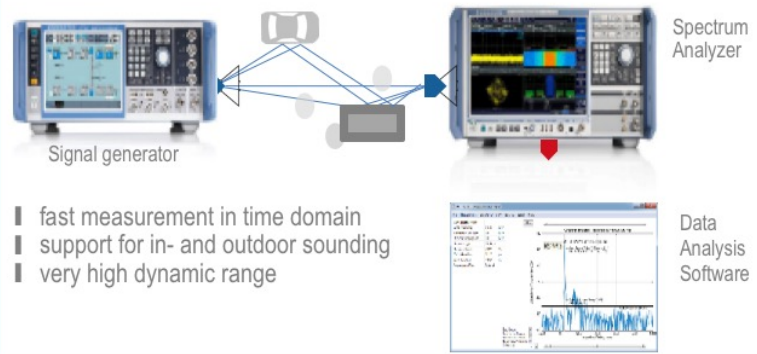
## **GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS**

What tools are available for the RF engineers ?

### Wideband Signal Testing



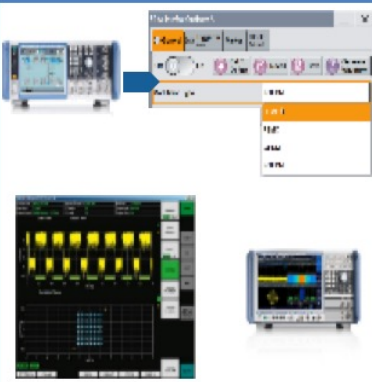
### Channel Sounding Solution



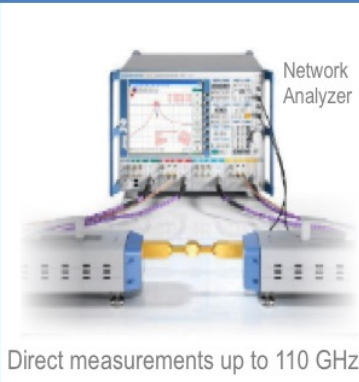
### Massive MIMO - Beamforming



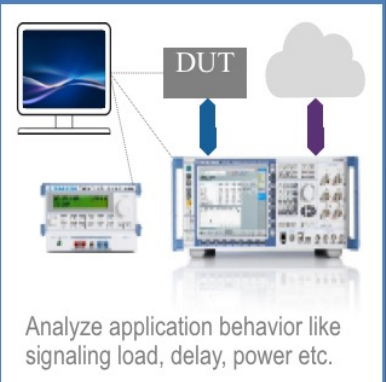
### New 5G PHY Candidates



### Component Characterization



### E2e Application Testing





# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Requirements For Modern Adaptive Students



# Requirements For Modern Adaptive Students

Fewer young people nowadays choose engineering education, and what is even more worrisome is the fact that the most gifted students decide to study at the faculties of computer science and engineering, choosing zeros and ones over microwaves or curl and divergence. The said zeros and ones are significantly easier to comprehend than the area of curl and divergence.





# Requirements For Modern Adaptive Students

Therefore, as a consequence, the computer students score higher than those who study the microwaves area, while putting, in fact, less effort into their learning. Difficult curriculum and fewer opportunities to obtain high grades cause the students to lose interest in microwaves.



# Requirements For Modern Adaptive Students

“The only person who is educated is the one who has learned how to learn and change”

The general demand to master new skills results from constantly modernizing technologies.

“The world does not pay for what a person knows. But it pays for what a person does with what he knows.”

Reference: Josef W. Modelski, MTT-S Microwave Magazine, August 2008

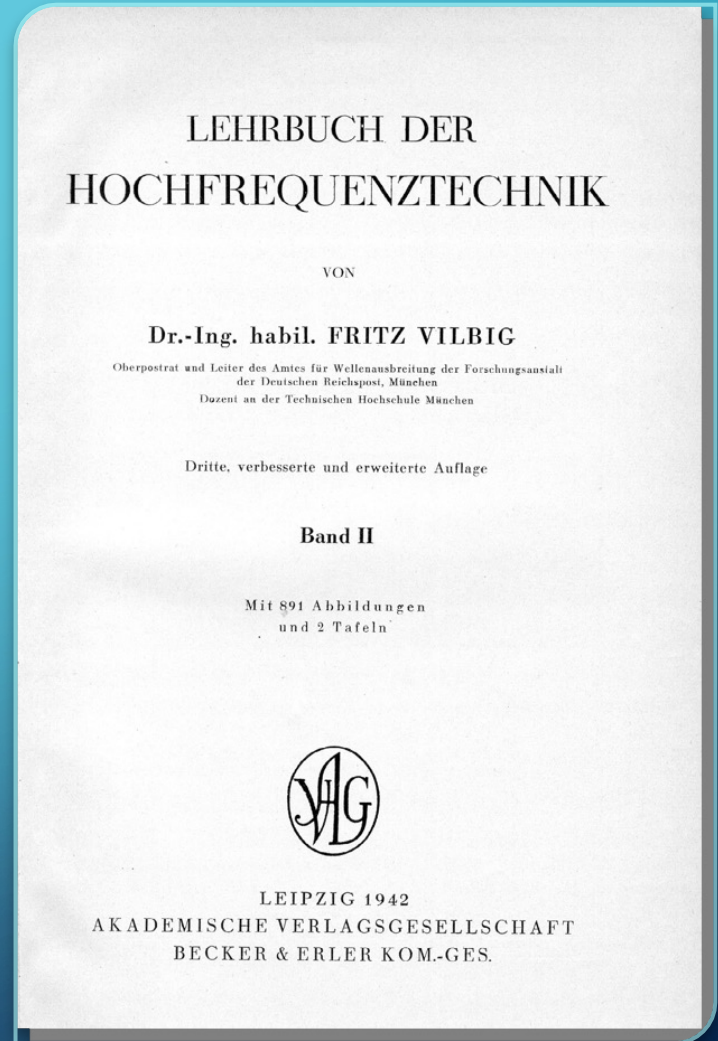


# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Literature

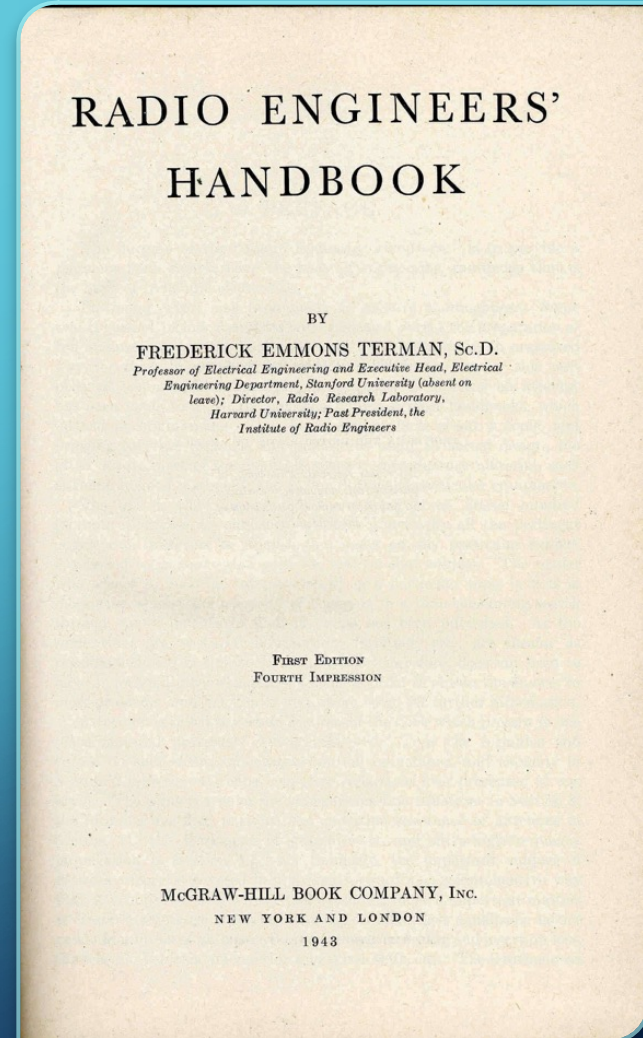
From 1942

- RF/Microwave Education (in German)
- Focus mostly on theory
- No international conferences
- No technology exchange or transfer due to language problems
- No digital technology (did not exist at that time)



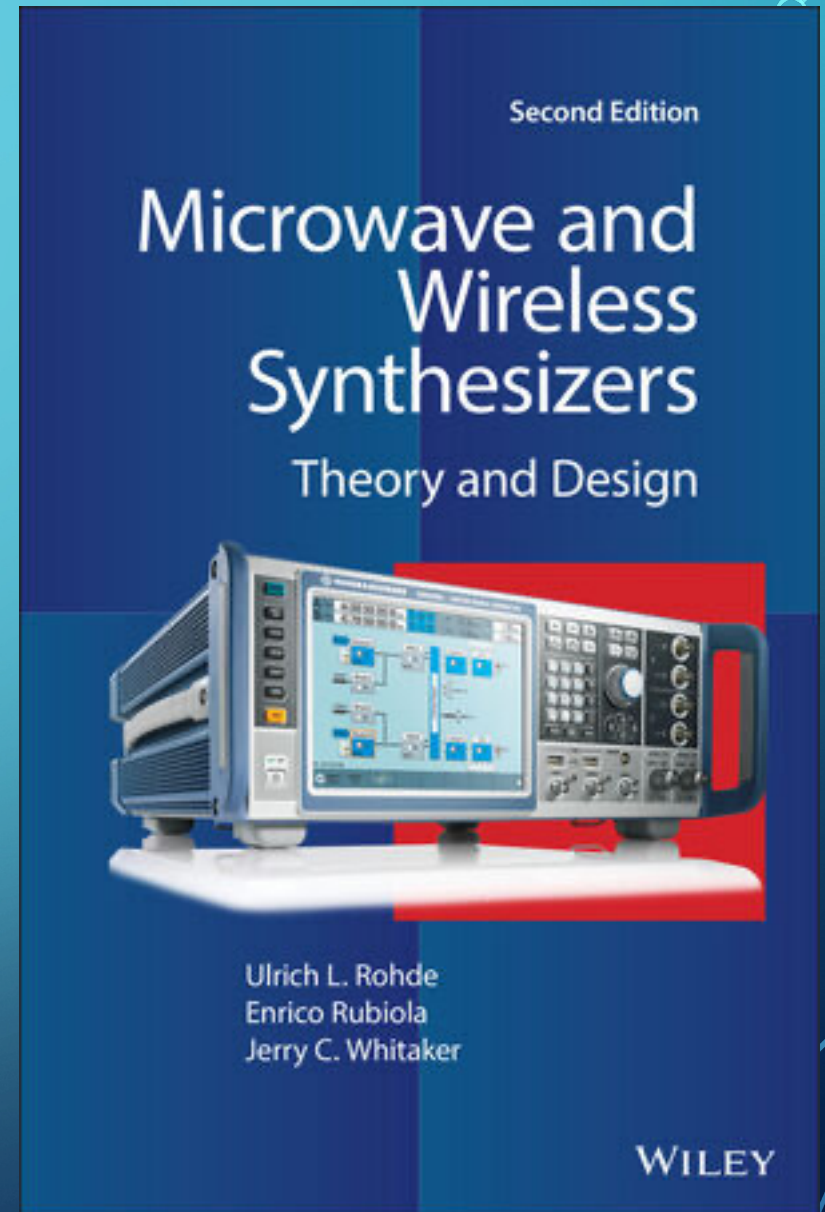
From 1943

- The State of the Art text book for radio engineering
- Probably the best comprehensive US radio electrical engineering book ever written. Used in all English speaking countries.
- Contains only analog circuitry  
(Digital technology did not exist at that time)



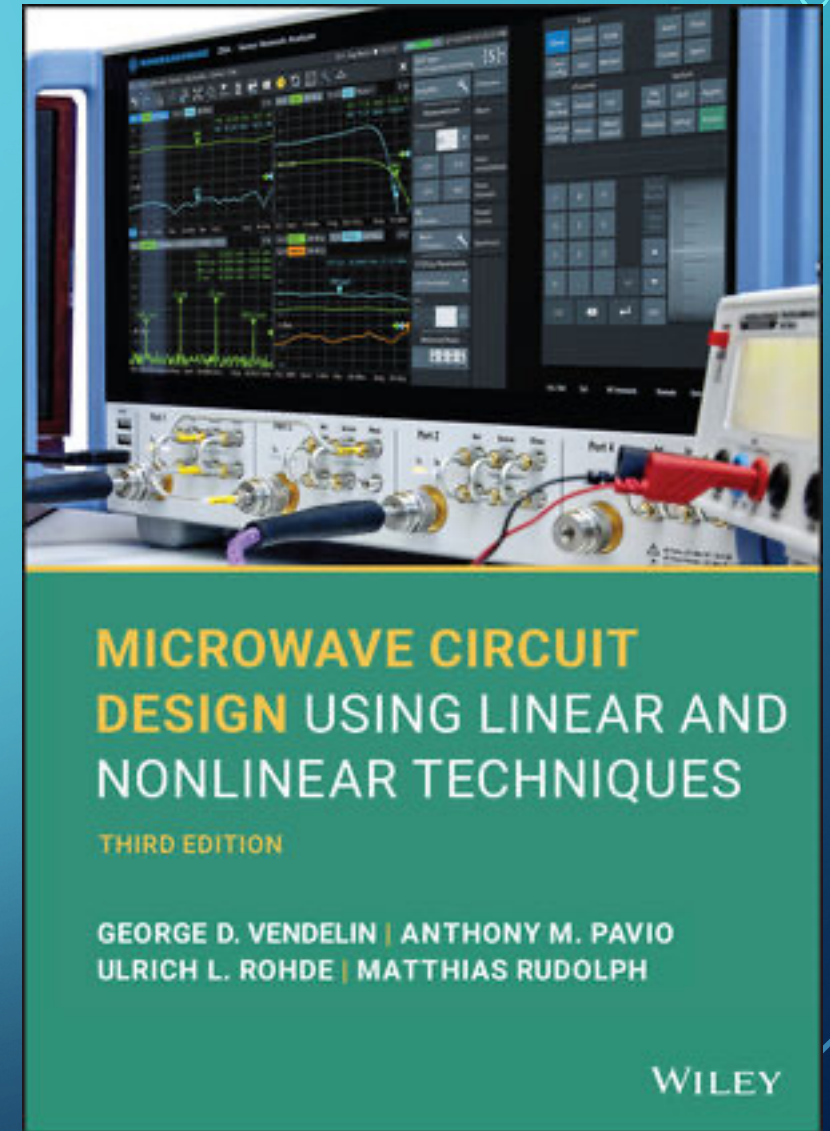
From 1997

- Microwave and Wireless Synthesizers-the first book to emphasize both practical circuit information from RF to millimeter-wave frequencies and up-to-date theory.
- In-depth look at the practical side of the phase-lock loop (PLL) in synthesizers-including special loops, loop components, and practical circuits-material
- Second edition 2021



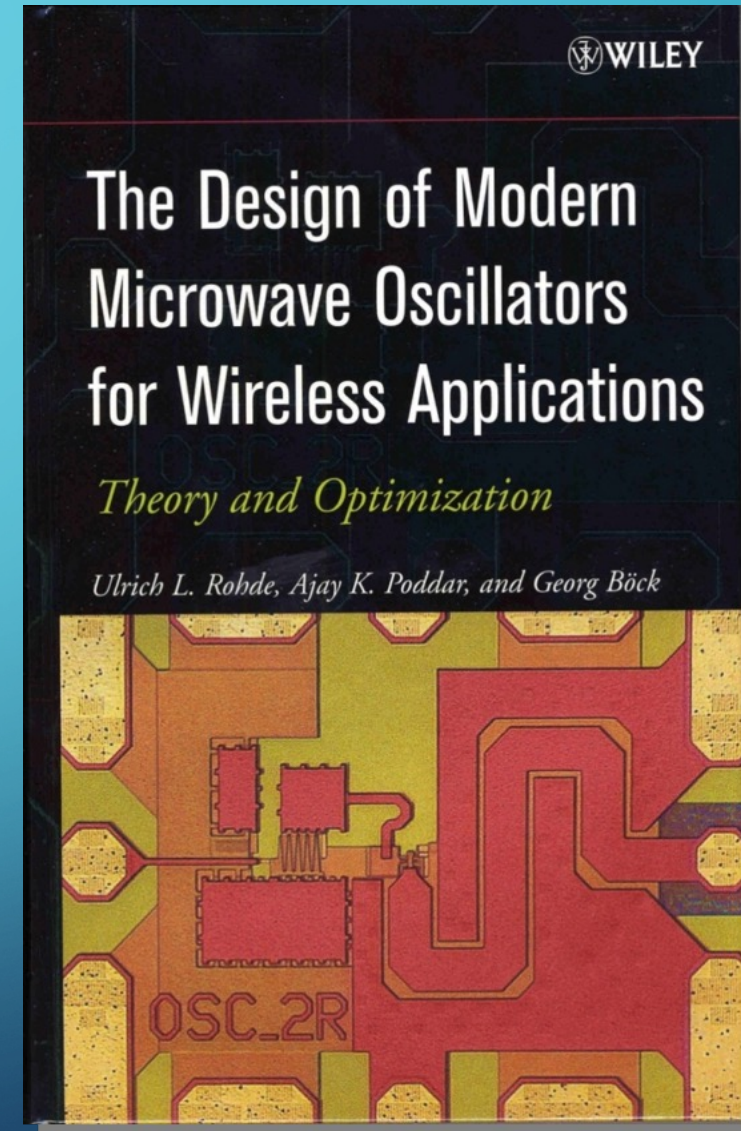
From 2005

- Linear and nonlinear circuit analysis treatment  
3rd edition 2021
- Best in class
- Covers all relevant material
- Ideal reference material



From 2005

- Oscillator performance can make or break a system performance
- Covers RF to millimeter wave circuits
- Most advanced text book on this topic
- Ideal reference material

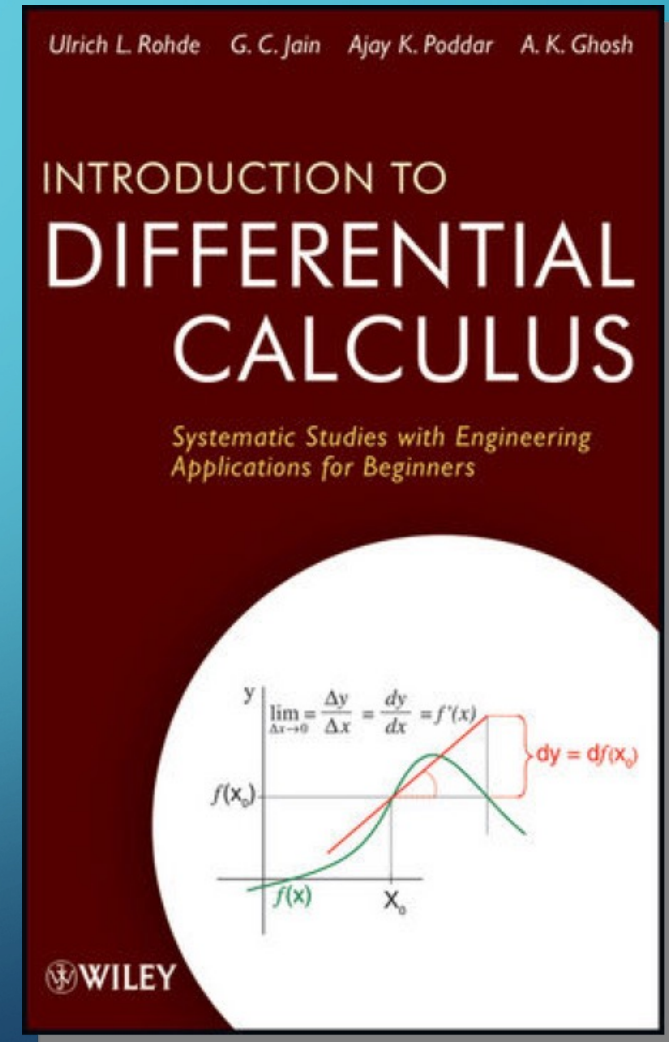




From 2012

Introduction to Differential Calculus fully engages readers by presenting the fundamental theories and methods of differential calculus and then showcasing how the discussed concepts can be applied to real-world problems in engineering and the physical sciences.

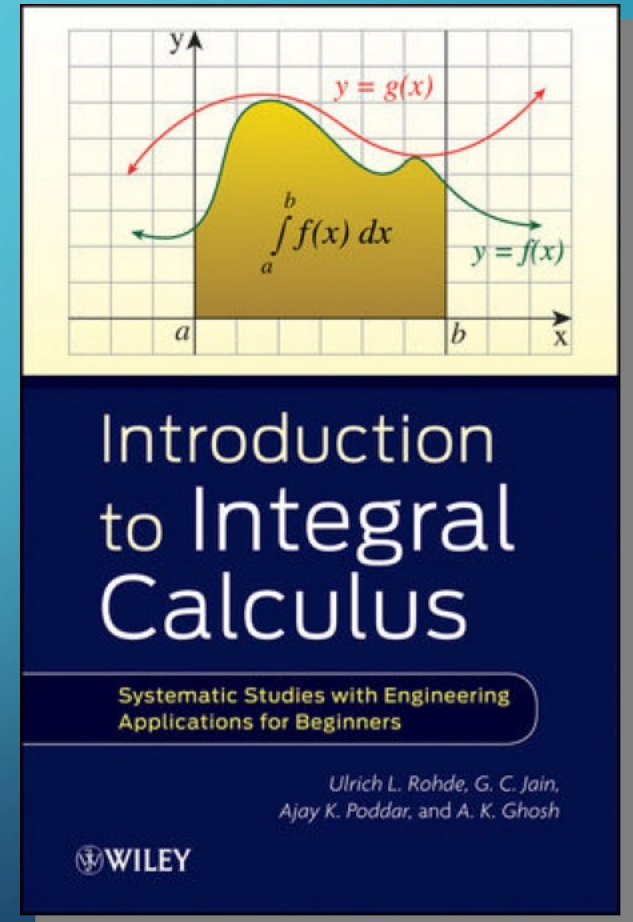
- Concepts of function, continuity, and derivative
- Properties of exponential and logarithmic function
- Inverse trigonometric functions and their properties
- Derivatives of higher order
- Methods to find maximum and minimum values of a function
- Hyperbolic functions and their properties



From 2012

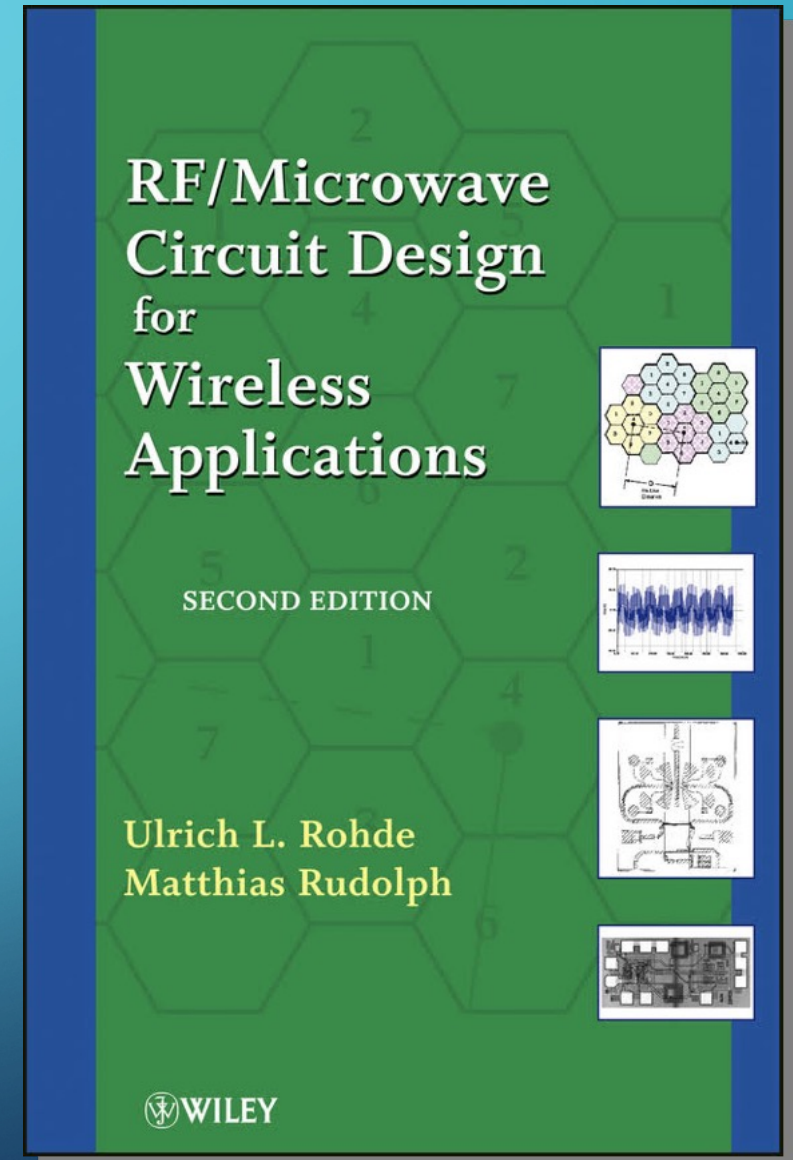
Integration is an important function of calculus, and Introduction to Integral Calculus combines fundamental concepts with scientific problems to develop intuition and skills for solving mathematical problems related to engineering and the physical sciences

- Mastering and applying the first and second fundamental theorems of calculus to compute definite integrals
- Defining the natural logarithmic function using calculus
- Evaluating definite integrals
- Calculating plane areas bounded by curves
- Applying basic concepts of differential equations to solve ordinary differential equations



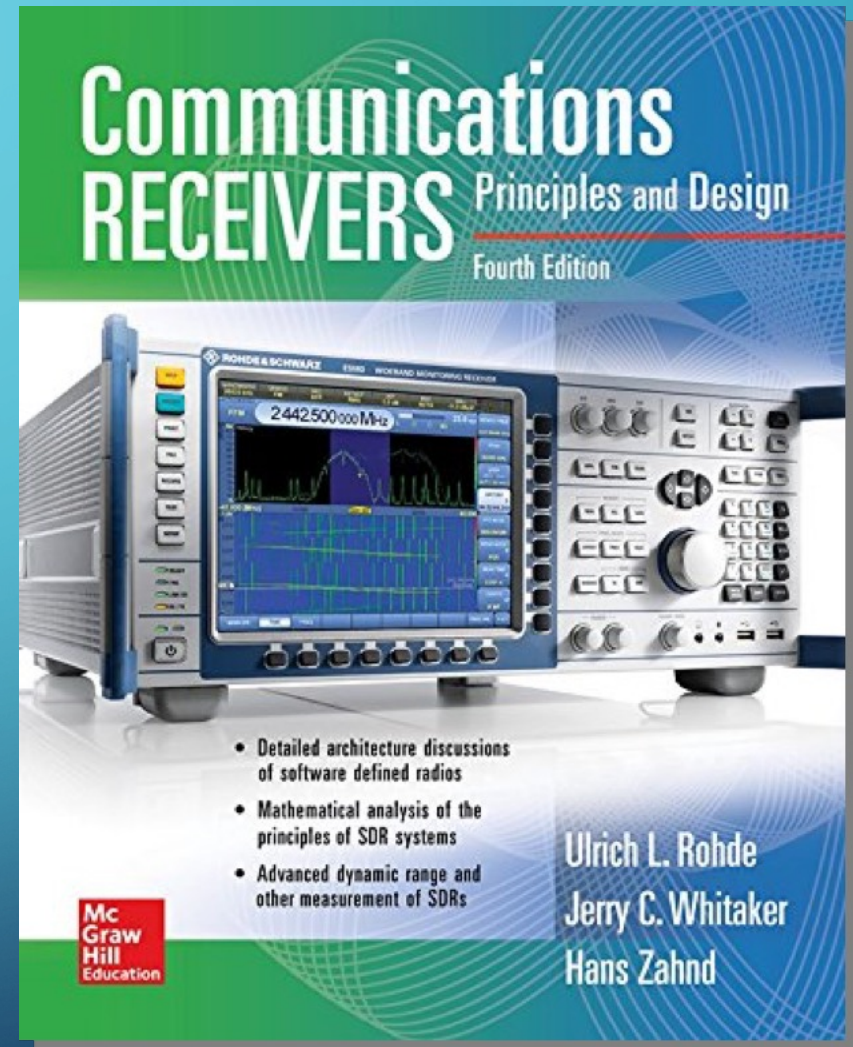
From 2013

- Education in English international technology language
- Focus on theory and real life application
- Material presented at international conferences
- Result of technology exchange or transfer
- Covers modern cellular radio technology, analog and digital



From 2017

- State of the art communication technology
- Covers high performance application
- Good reference for past and modern design

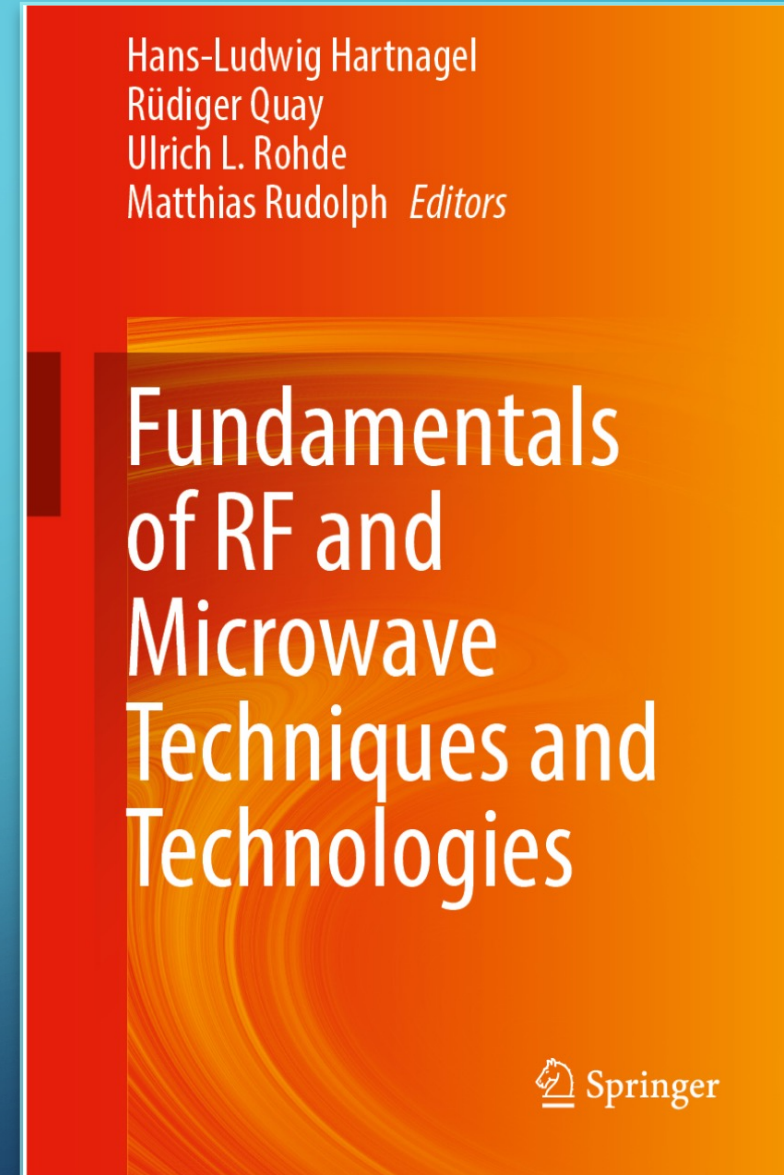


From 2022

Starting with the fundamentals it provides state-of-the-art theory, design, and applications of all RF and Microwave Techniques and Technologies

Covers:

- RLC circuits, transmission-line theory, antenna theory and noise statistics and physics
- Active microwave semiconductors, amplifier, mixer and oscillator circuits and SDR based systems
- Digital signal modulation schemes.

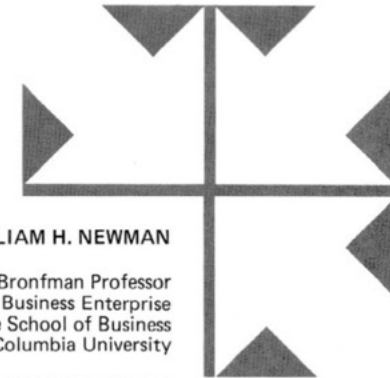


From 2009

- Success by implementing strategy, policies and central management
- Focus on market needs and cost effective manufacturing
- Watch your competitors at international conferences and adapt products
- Learn from technology exchange

# STRATEGY, POLICY, AND CENTRAL MANAGEMENT

Seventh Edition



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of Democratic Business Enterprise  
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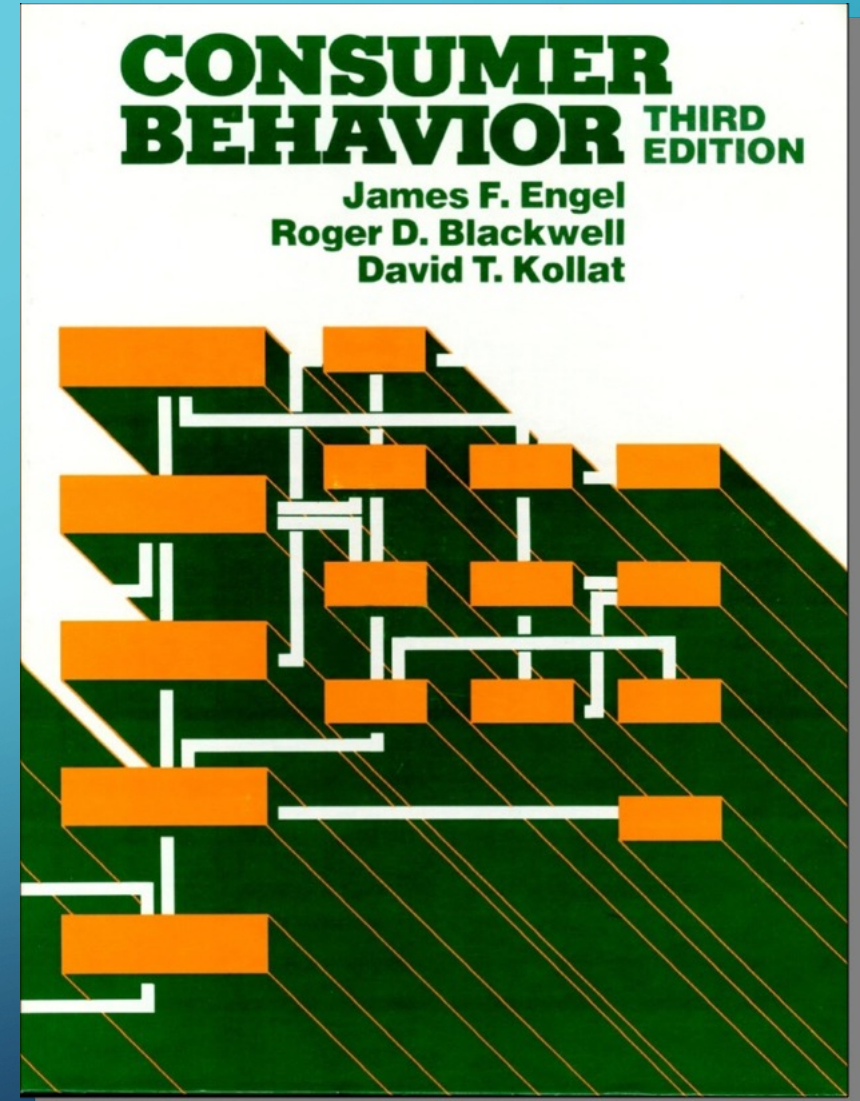
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CINCINNATI WEST CHICAGO, ILL. DALLAS PALHAM MANOR, N.Y.  
PALO ALTO, CALIF. BRIGHTON, ENGLAND

From 2009

- Success by watching consumer behavior
- Listen to the customers needs
- Decisions are made on perceptions more often than reality
- Compatibility with existing technologies or products is key to success



# Thank You



- You need a good mix between tradition and society demands
- Students come from all countries and become global professionals
- Country barriers are disappearing
- Success lies in education and commitment to excellency
- Good luck with all the Pomp and Circumstances !